Introduction to Wireless Network Planning

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Objective of Wireless Network Planning

There are many reasons as to why a wireless network is implemented, probably the most widely known wireless networks include cellular phone service and Wi-Fi, which for the most part are offered for convenience; however other wireless networks also exist, such as police and fire radio systems that assist public safety services to safeguard life and property, microwave backhaul networks which allow for large amounts of data to be transferred from one location to another without the use of cable or fiber networks, etc.

In general terms, the objective of wireless network planning is to design a wireless network that will achieve the minimum design requirements for the least cost.

Of course, achieving this broad objective can prove to be quite challenging depending on the region where the network is to be deployed, the technology of choice, and existing government or local regulations. One example could be an entity with a narrow choice of spectrum availability, which depending on co-channel usage, may not be able to deploy a critical site (even when all the other conditions are favorable). In this example, if the target area is of great importance, this entity may be forced to deploy two or more sites to achieve their coverage objective - therefore significantly increasing the costs of deploying the network. On the other hand, other entities may be licensed to use a portion of the spectrum throughout a wide area that may encompass even multiple States, making other challenges more significant - for instance, finding real estate suitable for installing communication sites.

Under these conditions, wireless network planning, will need to adapt in order to accommodate all the chaining variables that will force deviations in the preliminary design in order to arrive to a stable design. Notice it is not referred to as a "final design" because as technologies evolve, the network will evolve as well, making each stable design a stepping stone to another design.

Network Planning Technical Considerations

When planning a wireless network, there are a number of considerations that need to be accounted for and understood in order to have good design.

Let's review these from the perspective of the service provider:

Motivation - the motivation of the service provider relates to "why" the service provider intends to deploy a network. For example, the most common motivation is financial as in the case of Cellular or PCS operators that charge a fee for the use of their network to the general public. However, there are other motivations, as in the case of Public Safety entities, like police

departments, where their main motivation is a need to provide its users the ability to communicate reliably during an emergency.

Technology - the technology refers to "how" a service will be delivered to the users of the network, which will depend on the business nature of the service provider. In Public Safety wireless networks, APCO-P25 would be the latest technology used to deliver voice service over a digital network; on the other hand, for a Commercial operator, LTE or Long Term Evolution would be the technology of choice to deliver voice as well as high-speed data over a packet-only network.

Target area - refers to the geographical area, or "where" the service provider intends to cover with the wireless service. This is very important since this element will greatly influence the required number of communication sites, which will in turn have a direct impact on infrastructure costs. A target area could be a multi-state region, a city, a county, a highway, a port, a building, or a combination of these.

Level of service - refers to "what" type of service the operator intends to offer. For example, public safety operators generally offer voice service to its users, whereas commercial operators offer the ability to communicate in a number of ways that include voice, text messages, and data. However, as of the date of this writing, it is worth noting that recent changes in legislation may allow public safety entities to offer LTE service to its users on a nationwide level.

Schedule - refers the "when" the service operator will deploy its service offering. More importantly, how long it will take to accomplish this deployment and recover the investment. Take for example Provider 1 which plans to deploy one communication site a month in order to be able to reassign its workforce in a sequential manner, compared against Provider 2 capable of deploying ten sites simultaneously. When comparing these two scenarios, it becomes obvious that Provider 2 will have an advantage over Provider 1 (assuming all other variables are the same) because it will be able to monetize on its investment sooner as well as gaining first mover advantage. Of course there are many variable at play that would need to be planned for in a real deployment.

Challenges in Network Planning

Network planners are faced with a multitude of challenges, some can be surpassed in a matter of minutes, while others require more evaluation - this will all depend on whether the operator is deploying a new wireless network, expanding/enhancing their existing network, or perhaps targeting a new market. The following is a non-comprehensive list:

Financing - probably the most crucial of all challenges is the ability to find suitable financing sources that will keep a steady flow of cash throughout the project.

Sales and Marketing - also of great importance is the ability to evaluate existing offerings and identify and exploit unique characteristics that will make the new offering attractive to potential users.

Team - in order to properly represent the capabilities of the different departments, a properly selected team is important to make sure that all the initial assumptions have been validated from other perspectives. For instance, a marketing team may be interested in advertising, as a selling feature, that their service can be offered two levels below ground, and as such it becomes the responsibility of the engineering team to advise that what's being proposed can be accomplished by doubling or tripling the site density, which would require the finance department's input on feasibility. It may happen that such feature can be incorporated at a later stage in the network's optimization.

Tools for network planning - there are a variety of tools in the market. This challenge is more applicable to a new service provider, but it is this tool that will predict how the network behaves. For the most part, all these tools accomplish the same basic objective, which is the ability to perform coverage simulations. However, they vary in the in way they price the add-on features, such as:

- Compatibility with other tools - as an operator, do you require the planning tool to interface with a site database, or perhaps an external Geographic Information System (or GIS)? What about automatically open site survey information to assist in the site deployment process?
- Comprehensive equipment database - very important to be able to choose parameters from an approved list as opposed to be forced to look through catalogs for the required information.
- Database compatibility - will you be able to get freely available data or will you need to purchase unavailable data from a third-party vendor. Depending on the level of resolution and the type of data, this can be costly.
- Modularity - does the tool provide features that can be added at a later stage of the deployment process? For instance, the ability to adjust a propagation model with measurement data may not be needed until an actual site is deployed. Or perhaps, I may not need an intermodulation analysis tool until the team decides to collocate with another provider.
- Reporting capabilities - can the reports be customized or are the reports fixed. Is there an extra charge to build customized reports? Does it require the knowledge of other tools (i.e. SQL)?
- Support - depending on the location where the network is being deployed or designed, and where the vendor is headquartered, is support available when the planning team needs it. Think of a computer crash requiring the re-installation and re-licensing of the tool during a critical phase in the project.
- User interface - is the software intuitive? Would a user with experience using other tools be able to easily figure out the tool of choice?
- Training - is training available in the user's language? What about the documentation?

The link budget - is directly related to the technology of choice and how it will be modeled in order to estimate the minimum number of communication sites. For instance, a public safety entity that operates in the VHF band can have a single communication site reach ten miles or perhaps even more; on the other hand, an AWS site from a commercial operator may only reach a few miles. The link budget, will account for all the expected gains and losses, starting at one radio and ending on the other radio. More on the link budget later.

Facilities - refers to any existing infrastructure and its availability to be used in the design of the wireless network. For example, if the commercial operator is deploying into a new market, it is expected for facilities to be nearly non-existent; however if the operator is deploying a new technology over an existing network topology, then the existing facilities would need to be evaluated for availability. An operator may also be faced with the expansion of their network, where the existing network is simply being expanded either geographically or to provide wireless coverage inside buildings. An example would be an area that is undergoing a residential construction boom, where prior to this development, wireless coverage was considered acceptable while outdoors. When man-made obstructions came into the picture, these obstructions prevented the same wireless coverage from meeting user expectations indoors.

Real estate - refers to the ability to find available real estate to deploy a communications site. This topic is related to "Facilities", but more specifically, it refers to the actual search and validation of locations to install the communications equipment. It is for this reason that it is important for a network planner to understand the needs of the operator. The ability to have a list of potential sites may allow the "real estate" team to simultaneously look for sites during the design process. A list can be divided into the following categories:

- Available - the available sites are physical locations that have been pre-qualified and may include sites that are ready for deployment and sites that require some work to make it ready for deployment. These sites could be owned or leased. For instance, tower companies keep a database of their managed locations, and any interested party can contact in order to obtain information about a specific location.
- Potential - these are locations where a communication site exists, or where a property might provide a viable solution, but no information exists on availability or owner's interest to lease the location. These sites generally take longer to be ready for deployment.
- Search areas - these are the areas where a "greenfield" site was used in order to identify an area where coverage was required. A "greenfield" site refers to a hypothetical location that provide close to ideal coverage. These search areas take the longest to deploy because of the extra amount of work required to find a property owner willing to lease or sell a property, and the amount of time needed to have all facilities ready.

Other characteristics can be identified, but only become relevant depending on the provider's business plan.

Design Process - A High Level View

Prior to choosing the technology of choice, the business team would have performed a "Requirement Analysis" in order to determine the type of service offering they would like to provide potential users. For example, one requirement could be "offer 1 Mbps within 90% of the target area", or perhaps "offer 100 Mbps within 90% of the service area", or in the case of Public Safety "offer DAQ 3.4 voice quality within 95% of the service area with 95% reliability". Each of these requirements is extremely important as it would drive how the link budget is built and determine the range for each communication site. Other requirements include:

- Type of users to be served - voice users requiring real-time communications, or text messengers whose messages can be quasi-real-time, or perhaps video downloaders.
- Antenna heights of these users - the higher the user's antenna the better reception, but keep in mind that users typically have their cell phones on purses or pockets, in essence at belt level. In Public Safety, it is common to find shoulder height radio devices known as Speaker Mic Antenna or SMA.
- Primary and Secondary coverage areas
- Exclusion zones (i.e. near hospitals, radio observatories, etc)
- Reliability - is the network for commercial users or for more demanding Public Safety users?
- Services to offer (voice quality, data
- Desired site type (i.e. y to minimize costs is to deploy as mu tes when absolutely necessary, or site build out because land prices wil
- Spectrum avail needs to conduct frequency searc rcial wireless, this is either done thro ents between spectrum owners.
- Vendor selectio service provider have to go through a v
- Backhaul - depe may be fiber optic capacity available there is also the possibility to dep
- Financing - refers d under what conditions can the able to deploy 10 sites per month, o
- Marketing and sal der to develop a successful sales str
- Project manageme the project management team will be selected from within the firm (in-house) or subcontracted, or perhaps a mix of the two.
- And many other decisions that will impact when, how, what, and where the network will be analyzed, deployed, managed, optimized, expanded, and replaced.

Each choice will have a series of pros and cons, which will need to be carefully studied. Once the requirements have been defined, they will be passed to the planning team to interpret these wants and needs into technical parameters for the technology of choice. The network planning team will work closely with the real estate team in order to identify and qualify sites that will be used in the design. The real estate team will also be in charge of "hunting" for sites required to cover additional areas of interest.

After all the technical planning parameters have been taken into consideration, the team will be able to extract valuable information from the analysis. Depending on whether the operator is looking for Rough Order of Magnitude (ROM) information during a preliminary cost estimation exercise or an actual preliminary design that will be used as the basis for the implementation effort, the network planning team may be asked to do the following: